UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF ENTOMOLOGY

FOREST INSECT INVESTIGATIONS

FOREST INSECT CONDITIONS IN THE YELLOWSTONE NATIONAL PARK DURING THE SEASON OF 1925.

By

H.E. Burke
Associate Entomologist

U.S. Department of Agriculture.

P.O. Box 3010,
Stanford University, Calif.

March 16, 1926

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OUTLINE

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INTRODUCTION

During the past four or five years destructive forest insects have killed a number of trees in the various forests of the Yellowstone National Park. Realizing the importance of doing everything possible to stop the ravages of these pests, Superintendent Albright of the Park called for assistance from the Bureau of Entomology. In response to this call Mr. James C. Evenden, of the Coeur d'Alene station of Forest Insect Investigations, made several trips of investigation to the Park during the field seasons of 1923 and 1924. Dr. F. C. Craighead, in charge of Forest Investigations, accompanied Mr. Evenden on one trip made in July 1924.

As a result of the investigations made by Dr. Craighead and Mr. Evenden, it was decided to have an entomologist spend the entire field season of 1925 in the Park. The writer was detailed for this work. His orders were to study the habits of the lodgepole sawfly and the lodgepole needletyer, to direct the control work against these species, to investigate the spruce bud worm and any other forest insects reported to be killing timber and to recommend methods of control if control were thought justifiable.

The period June 6th to October 2nd was spent in the Park. Headquarters were established at the Riverside Ranger Station near West Yellowstone as it was in this section of the Park that the needletyer and sawfly infestation was located. Numerous trips were made to Mammoth, Camp Roosevelt, Yellowstone Lake, Canyon and various camps on the main looproad. A single trip was made to Sylvan Pass. Investigations were also conducted in the needletyer and sawfly infested areas of lodgepole in the Madison National Forest which adjoins the Yellowstone Park on the west.

SUMMARY OF GENERAL CONDITIONS FOUND

As a whole the forests of the Yellowstone National Park are in fair condition. There are several areas, however, where injurious insects have killed and are killing many trees.

Defoliators

In the vicinity of West Yellowstone, a needletyer, Enlia sp., and a sawfly, Neodiprion sp., working together, have killed large areas of lodgepole pine. Practically all of the trees on about 12,000 acres are dead and those on about 20,000 acres have been severely defoliated and are apt to die. The control work carried on against these pests in 1924 and 1925, along the highway between West Yellowstone and the Madison River Bridge, appears to have saved the trees which were treated.

During the past few years the spruce budworm, Cacoecia fumiferana, has killed many Douglas fir along the lower Yellowstone River between Tower Falls and Blacktail Deer Creek. At present it seems to have stopped its destructive work as during 1925 no defoliation could be found in the Douglas fir stands examined.

Barkbeetles

The Douglas fir beetle, Dendroctonus pseudotsugae, has killed several groups of Douglas fir at Camp Roosevelt and on the Tower Falls Mammoth road. Also a number of budworm defoliated trees that might have otherwise recovered. The control work against it carried on at Tower Falls during the spring of 1925 appears to have been successful.

The mountain pine beetle, D. monticolae, is killing white bark pine at Dunraven Pass and both white bark pine and lodgepole pine near Sylvan Pass.

The Engelmann spruce beetle, D. engelmanni, is reported to have killed numerous Engelmann spruce on Frank Island and Park Point on Yellowstone Lake. There are large groups of dead trees along the Sylvan Pass road between eleven and twelve miles from Lake Junction.

The fir beetle, Dryocoetes confusus, appears to have killed numerous alpine fir on Frank Island, Park Point, along the road near Sylvan Pass, and between Canyon Junction and Dunraven Pass.

Several species of smaller bark beetles, Ips oregoni, I. radiatae, Pityogenes knechteli, are killing lodgepole pine at various geyser basins and in the tourist camp grounds.

THE LODGEPOLE NEEDLETYER AND THE LODGEPOLE SAWFLY

Amount of Damage Caused

The needletyer, which is the caterpillar of a small moth, and the sawfly, the caterpillar of a small wasplike insect, have killed practically all of the trees on scattering areas throughout the upper valley of the Madison River in northwestern Wyoming and southwestern Montana.

Part of the area, about 54,000 acres, is within the Yellowstone National Park and part, about 46,000 acres, within the Madison National Forest. Practically all of the timber on 4,480 acres in the Park and on 7,680 acres in the Forest is dead while that on 8,960 acres on the Park and on 10,880 acres in the Forest has been severely defoliated and is apt to die. The timber on the remaining 48,000 acres of the area has received little or no defoliation and should live unless heavily defoliated in the future.

Location of Dead and Heavily Defoliated Areas.

Practically all of the heavily defoliated areas are in the area bounded on the south by the Ashton-West Yellowstone and West Yellowstone-Madison Junction highways; on the east by a line running along the Madison River above Old Riverside Ranger Station, along the hills which run north to Cougar Creek, along Cougar Creek to Maple Creek, then north to Gneiss Creek; on the north by a line running west on Gneiss Creek to Cougar Creek and then down Cougar Creek to the Hebgen Reservoir; and on the west by the Hebgen Reservoir and the South Fork of the Madison River. Several badly defoliated strips of timber cross the West Yellowstone-Madison Junction highway between West Yellowstone and the four mile post to the east. Badly defoliated and old dead areas are found across the Madison River about three miles from the present Riverside Ranger Station and about one mile from the old Riverside Ranger Station. A large old dead area occurs between Maple and Gneiss Creeks. Dead areas are found along the Park Boundary at the 25½ mile post and south of Gneiss or Duck Creek at the 28½ mile post. A large dead area occurs near the tip of the peninsula that extends west between the Hebgen Reservoir and the South Fork of the Madison River, and in the area that lies between the Park Boundary, Hebgen Reservoir and Cougar Creek. Some of these areas are crossed by the West Yellowstone-Bozeman Highway and the roads that lead to the Hebgen Reservoir and Horse Butte.

Type of Forest Injured.

Apparently the forest where the injurious defoliation occurs is a second growth that has come in after a heavy fire which occured about fifty years ago. The trees stand close together and appear of even age. Scattered among the smaller trees are larger trees belonging to an older stand. In many instances these have withstood the infestation while the second growth has been killed. In some cases, however, as in certain portions of the area south of the Hebgen Reservoir all of the trees in the stand have been killed. The forest appears to have been in good condition before the infestation developed and so far as could be determined the insects are the sole cause of the death of the trees.

Altitudinal Range.

All of the serious infestations are confined to the floor of the valley of the Madison River, between 6,500 and 6,800 feet elevation. Slight infestations occur in the forests above 6,800 feet but these have not caused any damage.

Nature of the Injury.

In its severest form the injury consists of a total destruction of the leaf surface of the tree. The needletyer works on the needles of the current year's growth while the sawfly eats all of the old needles. From this severe form all grades of injury occur. In the least severe attacks only a few new needles are tied together and destroyed by the needletyer, or a few of the older needles are eaten by the sawfly. Some trees which have received complete defoliation die the next year but others live for several years and apparently are able to survive several defoliations each more or less complete. A single defoliation, however, is a serious injury to a lodgepole pine and many defoliated trees never recover even though they may live for a number of years.

Life History and Habits of the Needletyer.

The needletyer is a small greenish caterpillar with three pairs of true legs and five pairs of false ones. It hatches from an egg laid on the convex side of a pine needle by a small brownish gray moth which has a wing spread of 5/8 of an inch. The egg is flat, oval, slightly corrugated and of a lighter green color than the needle upon which it is laid. The needle may be from one to five years old. The egg is laid in a group of from one to twenty-five, the average of 68 groups being 10. The eggs in the group usually are laid overlapping each other in two alternating rows near the middle of a needle. The overlapping of the eggs in the row and of the two rows give the group the appearance of being braided.

During 1925 the great majority of the eggs were laid between the fifteenth of June and the 10th of July.

The egg stage lasted for about nine days. The young caterpillar then hatched and crawled out on a needle and mined into it. Usually a needle of the new growth was chosen and the mine was made near the tip. After mining out most of the needle which took about two weeks, the caterpillar emerged from it and drew to it one or more needles and spun a tough web within the circle of needles thus forming a protecting tube. It lived within this tube feeding on the inner surfaces of the needles. Many tubes were being formed about the first of August. By the fifteenth of August the tubes became fairly conspicuous because the mined portions changed from green to whitish or greenish white. The caterpillars were now about 3/8 of an inch long. The tubes lined with their papery silken web were tough and not easily broken. They were open at the top and bottom so that the caterpillar could move quickly back and forward and easily escape if it was disturbed. When disturbed it often wriggled out and dropped down, hanging by a silken thread.

As feeding and growth continued more and more needles were joined to the tube until as many as twelve to fourteen were tied together and used for food. Some were cut off at the bottom and some at the top to form exits for the caterpillar. By the last of August many of the needles had most of their inner surfaces destroyed and had turned brown. Most of the tubes were formed from the needles of the current year, but a few were formed from those of the preceding one. In some cases all of the needles on a twig had been formed into tubes and the tree was practically defoliated. As many as twelve caterpillars were found on some twigs.

Soon after the first of September most of the caterpillars became full grown. Often they were seen reaching out from their tubes to other needles for a few final meals. As soon as they were full grown they left the tube and went to the ground under the trees where they crawled around until they found a suitable place for changing to the chrysalis stage. In changing to the chrysalis a slight web was formed between several old needles or among some some scales just beneath the surface of the forest floor. The transformation to the brown mummy like chrysalis took place within this web.

By October first most of the brood was in the chrysalis stage but there were still some caterpillars in the tubes and some crawling around among the fallen needles on the ground. By this time, at West Yellowstone, there had been several snow storms and practically every night the temperature had been below freezing.

Apparently the needletyer remains as a chrysalis over the winter until about the first of June of the next year. It then transforms to a moth which emerges from the chrysalis, mates, and if a female, deposits its eggs on the needles of a lodgepole pine tree to start a new generation of caterpillars. The moth as it rests on the twig of a lodgepole pin closely resembles one of the unopened buds.

Life History and Habits of the Sawfly.

The sawfly caterpillar is a greenish or grayish green smooth "worm" marked by lighter stripes along the sides and the back. It has three pairs of true legs and eight pairs of false ones. The head is dark brown and the eyes are conspicuously black. The fullgrown caterpillar is about one inch in length. The caterpillar hatches from an egg laid by a small, brownish, wasp-like insect about 5/16 of an inch long and with a wing spread of 3/4 of an inch. The male is smaller, about 4/16 of an inch in length, and black with the antennae many branched.

The egg is laid in a shoe shaped pocket cut into the edge of a lodgepole pine needle by the female. From two to eleven eggs are laid in each needle attacked, the average number laid in 150 needles examined being seven. In 1925 most of the eggs were laid during the period June 15 to July 15th. Practically all were laid in the needles of the previous year's growth.

About one month after being laid the egg hatched and the young caterpillar emerged into the outer world. All of the eggs in one needle hatched about the same time. Just before hatching the swelling of the egg split the edge of the needle just over the shoe shaped pocket so that the young caterpillar met with practically no resistance when it came out of the egg.

The young caterpillars keep close together. Usually they are found lying longitudinally along a needle with their heads toward the tip. Often they lie so close together that they touch each other and form a complete circle around the needle. In feeding they eat irregular patches of pulp from the outer surface of the needle and sometimes they strip the pulp completely off leaving only the mid rib. When they get larger they eat the entire needle down to the sheath. Most of the feeding of the sawfly caterpillars is done on the older needles but they will eat those of the current year's growth.

Although most of the sawfly caterpillars disappeared during the summer of 1925 the indications are that under normal conditions they become fullgrown about the middle of September and go to the ground to pass the winter. As soon as each gets under the top layer of the old needles that cover the ground and finds a suitable place, it spins a tough brownish parchment-like cocoon around itself and shortens up into a dark green, quiescent grub. It remains in this stage until the following spring or even the second spring before it pupates and transforms to a sawfly. Part of the caterpillars of the 1924 generation transformed to sawflies and emerged in June 1925 but numbers of them are still in the cocoons and probably will not transform and emerge until the spring of 1926.

Control Work.

The first control work against the needleteyer and the sawfly was conducted during the period July 25 to August 10, 1924, under the direction of Mr. Evenden. The trees around the Oregon Short Line station at West Yellowstone and for 150 to 200 feet on either side of the main highway from the Western Entrance of the Park to the five mile post toward Madison Junction were sprayed. The formula used was twenty-five pounds of powdered arsenate of lead and one gallon of raw linseed oil to each four hundred gallons of water. Six thousand pounds of arsenate of lead and 240 gallons of linseed oil were used. The work was done with a crew of six men and a large Fitzhenry-Guptil motor truck sprayer borrowed from the Gypsy Moth and Browntail Moth Investigations of the Bureau of Entomology. Part of the time a motor truck water tank was used as an auxiliary water carrier.

Although the spraying was done rather late in the season because the sprayer had to be shipped from New Jersey after the Gipsy moth control work was over, the results obtained were very good. All of the trees along the highway were saved and in many places a distinct line could be drawn between the sprayed areas in the highway zone and the unsprayed areas just outside.

Since the areas sprayed in 1924 were reinfested during June 1925 by moths and sawflies from the unsprayed outside areas, further control work was carried on under the direction of the writer during the period July 16-21, 1925. A strip of timber averaging one hundred and fifty feet on either side of the highway from the Western Entrance to the first bridge across the Madison River, a distance of about seven and one half miles, was sprayed. Thirty-seven hundred pounds of arsenate of lead, one hundred and fifty-eight gallons of oil, and fifty-nine thousand and two hundred gallons of water were used. The spraying was done with the Fitzhenry-Guptil motor truck sprayer, a motor truck sprinkling cart used for a water carrier and a crew of nine men.

Although, as in 1924, due to inability to get the sprayer sooner, the work was done too late to stop the early work of the insects, the results are very good. The trees along the highway have been saved for another year while many of those outside of the sprayed areas have been killed.

Parasites.

Parasites of the needletyer and the sawfly were not common during 1925. Several paper-white cocoons of a Braconid parasite of the needletyer were taken. The parasite larva leaves the full grown larva of the needletyer and spins its cocoon among the needles. One small dipterous puparium was found in a cocoon of the sawfly and one Ichneumon fly was reared from another cocoon. Several adult sawflies were found which had been attacked and overpowered by a species of mound building red ant.

Recovery of the Forest.

Although lodgepole pine reproduces faster where the soil is uncovered, as after a fire that cleans off all of the fallen needles, there is no reason why the forest in the defoliated areas should not come back in a few years. The probabilities are that the new forest will grow better than the old because the reproduction is not apt to be so thick and the individual trees will not be starved by over crowding.

THE SPRUCE BUDWORM.

Conditions in the Spruce Budworm area are about the same as those described by Mr. Evenden in his report of October 22, 1924. Numerous Douglas Fir trees in areas at the base of Crescent and Garnet Hills and down the Yellowstone River to Blacktail Deer Creek have been killed by the defoliations and by the subsequent attacks of the Douglas fir beetle. During the season of 1925 there was no noticeable defoliation by the budworm. A few chrysalids were collected at the base of Crescent Hill on July 22nd. These produced moths during July. No eggs or young caterpillars could be found in September and there is every indication that the budworm epidemic in this region is a misfortune of the past.

Many of the trees, severely defoliated and moderately defoliated by the budworm, are being attacked by the Douglas fir beetle and will be killed. Trees under six inches in diameter that were severely defoliated died from the defoliation. Trees six to ten inches in diameter survived the defoliations very well and appear to have resisted the first attacks of the Douglas fir beetle or were not attractive to them. Trees over ten inches in diameter survived the defoliation very well but were attacked and killed by the Douglas fir beetle.

Budworms were not found at Camp Roosevelt nor along the highway from Tower Falls to Mammoth.

Parasites.

One small Ichneumon fly, one Braconid, and one Dipterous puparium emerged from chrysalids of the budworm collected at Crescent Hill on July 22, 1925.

THE DOUGLAS FIR BEETLE.

The Douglas Fir Beetle is killing many trees in the budworm defoliated areas. Present conditions indicate that the great majority of the trees which have survived the defoliation will be killed by the beetle in the next few years. Trees over ten inches in diameter were attacked first and many are now dead. Trees from six to ten inches in diameter appear to the the least attractive or the most resistant and were not attacked in numbers until the fall of 1925. On September 17th, however, many of these smaller trees were found with a brood of developing beetles under the bark of the main trunk. On this date most of the brood was in the young beetle stage but there were a few pupae and some larvae.

The control work carried on in 1924, against the beetle at Camp Roosevelt, under the direction of Mr. Evenden, appears to have been a complete success. A thorough examination of the area back of the Camp made September 16th failed to show a single infested tree. Seven old redtop abandoned trees were found on the hillside back of the barns.

A group of seventeen infested trees, 12 - 30 inches in diameter, were found on the hillside south of the road about sixteen miles east of Mammoth or about two miles west of Camp Roosevelt. The brood was in the young beetle stage and will emerge to seek live trees during the spring of 1926. Whether this infestation came from the budworm area at the foot of Crescent Hill could not be determined, but it appears very probable, since that area is only about one mile distant.

THE MOUNTAIN PINE BEETLE

During the summer of 1924, several active infestations of the mountain pine beetle started in lodgepole pine and white bark pine at high elevations, 8,500 to 9,000 feet. Scattering red topped lodgepole and white bark pine trees or small groups of trees could be seen along the road from Sylvan Pass to Cub Creek. Some of these trees had produced large broods of beetles and some were infested. The main center of infestation appears to be near Cub Creek. Numerous groups of red trees could be seen on the hillsides around the valley. One typical looking group examined contained eighteen pines. Twelve white bark pine and one lodgepole were dead, two whitebark and three lodgepole were infested and dying. The whitebarked pine showed foliage yellowing but the lodgepole were perfectly green. All showed white or reddish pitch tubes on the bark of the main trunk. On September 15th, parent adults, eggs, and young larvae were found under the bark.

A very active infestation was found in the whitebark pine around the Mt. Washburn Ranger Station at Dunraven Pass, altitude 8,800 feet. Twenty-one bleak topped trees, abandoned, probably killed in 1923, 28 red topped abandoned, probably killed in 1924, and 14 green dying trees, infested in 1925, were found close to the Ranger Station. Scattering red topped trees were seen on the hill sides toward the summit of Mt. Washburn and along the road toward Tower Falls. The infestation appears to have started from some trees injured by the grading of the Dunraven Pass-Tower Falls road. The injuring of small groups of trees by the grading of the road probably concentrated the small broods of beetles scattered through the surrounding forests. The broods developing in the injured trees attacked and killed nearby living ones and thus started an active infestation. On September 15th, parent adults, eggs and young larvae were found under the bark of the green dying trees.

THE ENGELMANN SPRUCE BEETLE.

In his report for 1924, Mr. Evenden says that from 60 to 70 percent of the mature Engelmann spruce on Frank Island and on Park Point to the east has been killed by bark beetles during the past five years. No new attacks were found and all of the evidence obtained indicated that the epidemic was on the decline.

The writer was unable to visit Frank Island during 1925 but found some evidence of this same or a similar infestation along the Lake Junction - Sylvan Pass road. Between the eleven and twelve mile posts toward Sylvan Pass a group of about thirty dead spruce were found which had been attacked and killed by the Engelmann Spruce beetle. Several hundred old dead trees were seen in a bottom at some distance from the road. No newly infested trees could be found. All of the evidence indicates that the infestation is not now active and that the conditions mentioned by Mr. Evenden are general throughout the Park directly east of Yellowstone Lake.

THE FIR BEETLE.

In his discussion of the Engelmann Spruce beetle in the report for 1924, Mr. Evenden also says that a large percent of the alpine fir on Frank Island and east of there has been killed by bark beetles. Dying Alpine fir along the Lake Junction - Sylvan Pass road became conspicious during the late summer of 1925. During an examination made September 15, numerous groups of five to six or more red topped trees were found from Sylvan Pass west to Cub Creek. Cub Creek appeared to be the center of the the infestation, groups of as many as fourteen red topped trees being found. Most of the infested trees contained a healthy brood of the fir bark beetle in the inner bark. Larvae, pupae and young beetles were found. Some trees contained mostly young beetles.

On September 16th, about three miles from Canyon Junction, 20 to 30 redtopped fir were seen below the road along one of the branches of Sulphur Creek. These trees appeared to be in the same condition as those examined near Sylvan Pass.

All of the evidence obtained so far indicates that there is an extensive dying of the alpine fir throughout the Yellowstone region which is accompanied by an infestation of the fir bark beetle. Whether this insect is the primary cause of the death of the trees or not was not determined.

DYING TREES AROUND GEYSER FORMATIONS AND IN CAMP GROUNDS

The forests around most of the camp sites and the geyser formations look rather ragged because of numerous dead and dying trees. At the last examination of these areas made September 14 to 17 the following conditions were found:

Fountain Basin, south end. 52 dead and dying trees; 50 are red, 2 yellow; 4 infested with Ips oregoni, mostly in young beetle stage, but numerous pupae in some trees; Ips radiatus adults at base of one tree.

Excelsior Basin, south end. 11 dead and dying trees in one group; 6 red tops, 5 black tops; Ips oregoni work common under bark.

Upper Geyser Basin, Daisy Geyser. Group of 15 lodgepole dying. Few insects in one. Hot water appears to be the cause of the death of most of these trees.

Emerald Pool. 2 yellow tops, 3 red tops, 10 black tops; no insects. Hot water appears to be the cause of the trouble.

Emerald Pool to Old Faithful. About 100 red tops.

Thumb 72 red tops cut in September. Ips oregoni and Ips radiatae in some of these, Pityogenes knechteli in some.

Lake Public Camp. 45 blacktops, 23 red tops; Ips oregoni work in some.

Camps Company Camp. 59 black tops. 23 red tops; Ips oregoni work in some.

Fishing Bridge Camp. 135 black tops, 47 red tops, lodgepole; 2 black tops, 17 red tops, Alpine fir. Most of dead lodgepole show work of Ips on wood. One green tree had been attacked by the mountain pine beetle but the attack failed.

Mud Volcanoes. 641 black tops, 188 red tops, 34 yellow tops; some of these trees show the work of Ips oregoni, a few the work of Ips radiatae and some of the small ones the work of Pityogenes knechteli. Apparently the change in the flow of one of the hot springs killed a number of trees. The scattered beetles in the surrounding forests were attracted to the area. These beetles attacked the dying trees and developed healthy broods, which upon emerging, attacked the surrounding uninjured trees and continued the infestation.

Appollinaris Spring. Scattering red tops, lodgepole and Engelmann spruce; mostly the work of porcupines.

Roaring mountain. 150 black tops, 50 red tops, lodgepole. Forest looks very ragged. Hot water is the principal cause.

Norris Basin. There are some red tops and black tops, lodgepole, on the Norris Basin formation areas but no evidence of extensive insect infestation. At several places between Norris Junction and Madison Junction there are groups of dead trees caused by hot water or cloud bursts. These trees show signs of Ips work but do not seem to have caused active infestations.

Whether or not the condition of the trees around the geyser formations and the camp sites can be improved is a question. The environment certainly is not normal for the best growth of trees. In the geyser areas the hot water often changes its course and kills trees. If there are scattering insects in the surrounding areas they will be attracted to these trees and under favorable conditions will rear heavy broods which upon emergence will attack and kill the nearby live trees. Such an infestation continues for several years when the broods gradually scatter again until the next change of the flow of water kills some more trees.

In the camp sites the trees are injured by the packing of the soil, by the exposing of the roots, by the scorching from many camp fires and by various injuries inflicted by the numerous tourists that use them for one purpose or another. These direct causes of lowered tree vitality and the building of new buildings form attractive influences which draw in the Ips and other secondary insects scattered throughout the surrounding forests. These attack the weakened trees and develop infestations as around the geyser formations.

In both cases the causes of the insect infestations are apt to continue. All that man can do is to make the conditions for tree growth as favorable as possible and the conditions for insect development as unfavorable as possible. The dead and dying trees should be removed and those infested with insects burned. Building should be done in the fall after the flights of the insects are over for the year. Signs informing the public that injured trees will die, might prevent some damage.

RUSTIC INSECTS

The general policy of the Park Service is to have all buildings for the use of administration officers or concessionaires conform to the natural surroundings. Many present buildings are built of logs. Where the bark is left on, as at the Mammoth Camp of the Camps Company, roundhead and other bark borers have caused some trouble. The dust made by the borings falls down into tables, chairs etc., and the bark becomes loosened and ragged looking. Where the buildings have been built of peeled logs no trouble has been reported. It, therefore, seems probable that if all future buildings are built of peeled logs the trouble will be stopped.

RECOMMENDATIONS

The investigations carried on by the writer during the season of 1925 indicate that the following operations should be conducted by the Park Service during the fall of 1925 and the spring of 1926:

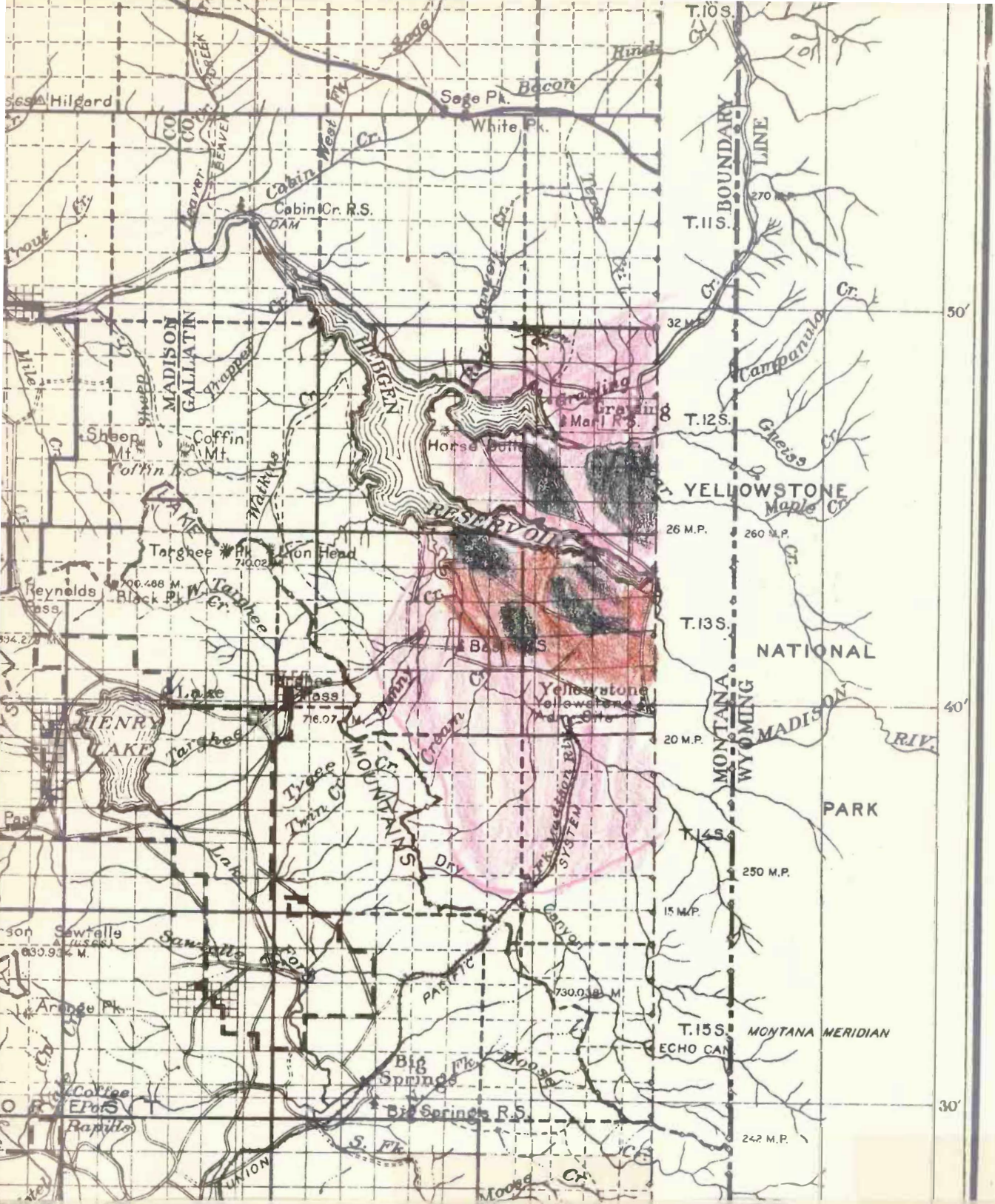
(1) The trees for 150 feet on either side of the highway between West Yellowstone and the Madison River bridge should be sprayed in June 1926. The spraying conducted during the past two years has been conducted too late to control the needletyer larvae before they have caused considerable injury to the trees. In order to do the spraying at the proper time the Park Service should own a sprayer. It is estimated that the spraying will cost $5,000 and a suitable sprayer $7,500 to $10,000.

(2) The infested Douglas fir along the Mammoth-Tower Falls highway about sixteen miles from Mammoth, should be treated by felling and barking or burning before June 1, 1926. The cost will be $100.

(3) The infested whitebark pine around the Mount Washburn Ranger Station should be treated by felling and barking or burning before July 1, 1926. The cost will be about $200.

(4) The dead and dying trees around the geyser formations and the camp sites should be felled and burned before July 1, 1926, to see if the continual killing of the trees on these areas cannot be stopped to a great extent. This work is experimental but the amount of annual loss now occuring, justifies the expenditure of the amount estimated. The cost will be $1,400.

(5) The Douglas fir barkbeetle infestations in the budworm areas along the lower Yellowstone River, the Engelmann spruce infestations east of Yellowstone Lake, and the fir bark beetle infestations near Sylvan Pass should be watched closely for developments. Control work against them does not appear to be justified at present.



Map of section of Madison National Forest showing approximate areas infested by the lodgepole needletyer and the lodgepole sawfly in 1925. Pink- Area in which some infestation was found. Brown- Areas where the defoliation is serious. Black- Areas where practically all of the trees have been killed by the defoliation. Scale, one fourth of an inch to the mile.


Snowshoe Cabin
Carnelian Creek
Indian Creek
White Peaks
Snowshoe Cabin
Maple
MADISON
VALLEY
Cougar Creek
Duck Creek
West Yellowstone
West Yellowstone Ranger Station
Riverside Ranger Station
Purple Mtn
Terrace Spring
MADISON RIVER
Mt Haynes
Cascades of the Firehole
MADISON PLATEAU
Sentinel Creek
Queens Laundry
Twin Buttes
Snowshoe

A.- Female sawfly. Enlarged 5 times.

B.- Male sawfly. Enlarged 5 times.

C.- Egg pockets of sawfly in lodgepole pine needles. Left, one year old work. Center, fresh work. Enlarged 2 times.

D.- Well grown sawfly caterpillars. Enlarged 6 times.

E.- Resting caterpillar and cocoons of sawfly. Enlarged 4 times.

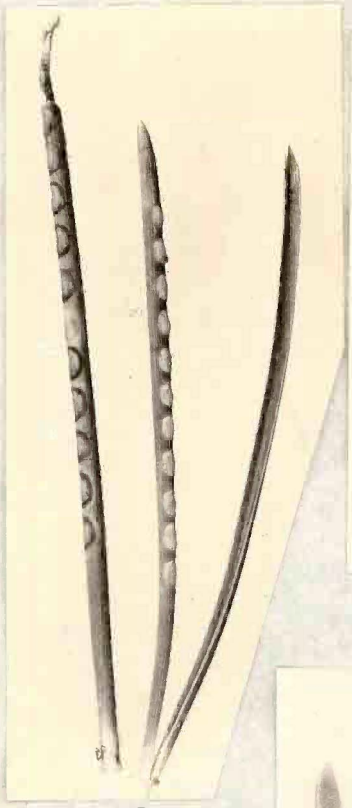
F.- Sawfly caterpillars and their work on a lodgepole pine twig. Enlarged 3 times.

Photo C by J. E. Patterson. Others by Photographic Laboratory of Bureau of Entomology.

Yellowstone National Park, 1925. Plate I

A

B



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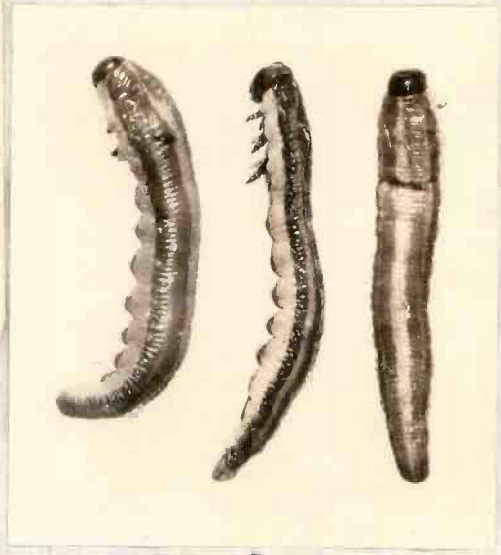
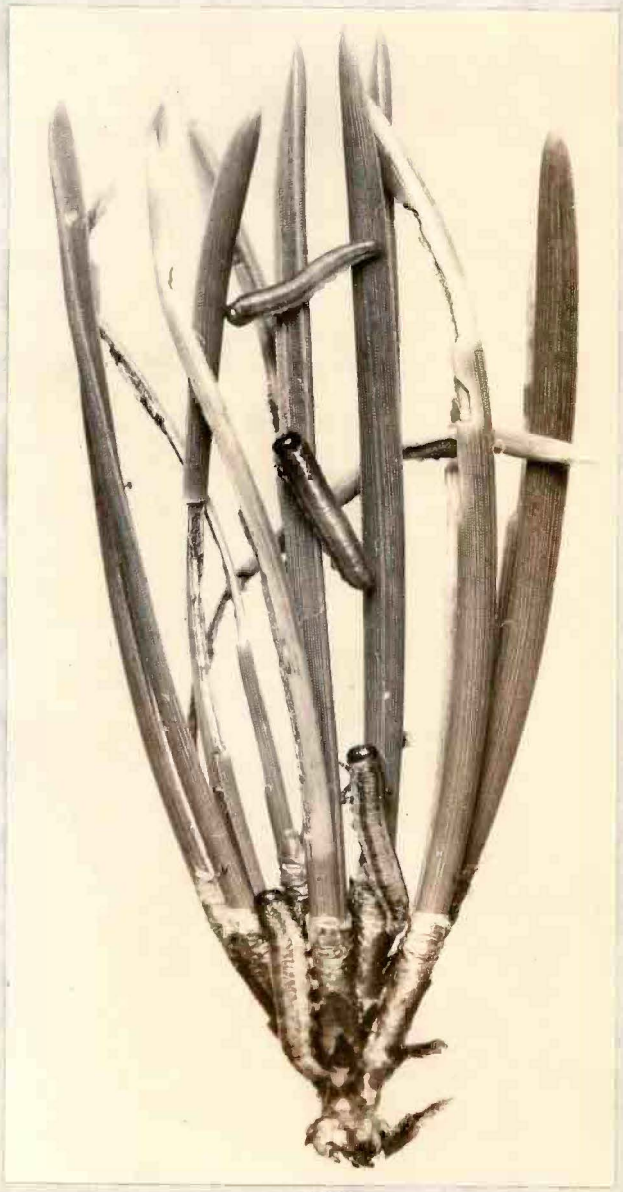


D

E



F

A.- Needletyer moth and chrysalis from which it has emerged. Enlarged 6 times.

B.- Group of needletyer eggs on a lodgepole pine needle. Not a good resemblance as eggs have shrunk. Enlarged 20 times.

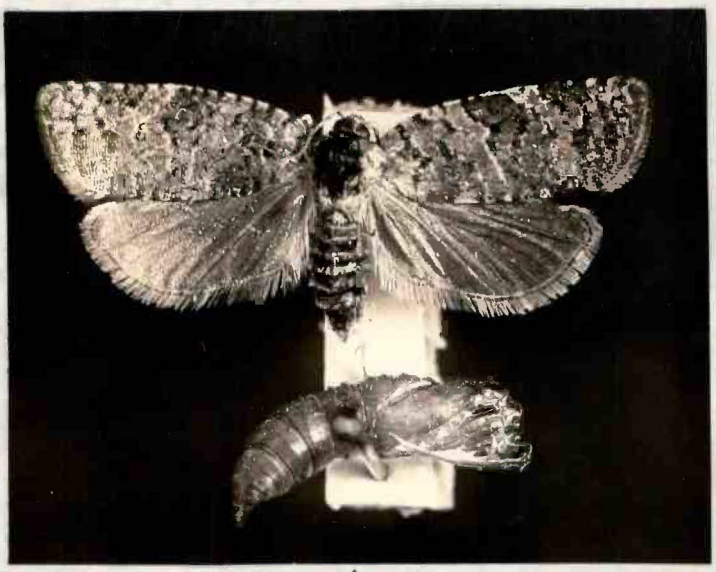
C.- Well grown needletyer caterpillars. Enlarged 5 times.

D.- Needletyer chrysalids. Enlarged 7 times.

Photographs by Photographic Laboratory of Bureau of Entomology.

Yellowstone National Park, 1925.

Plate II



A

B

C

D

A.- Lodgepole pine twig showing work of needletyer caterpillar. Center, five bundles of needles tied together to form one caterpillar's tube. Enlarged 4 times.

B.- Lodgepole pine twig showing needles tied together to form tubes for the caterpillars. Center, cocoon of parasite of needletyer caterpillar. Enlarged 4 times.

Photographs by Photographic Laboratory of the Bureau of Entomology.

Yellowstone National Park, 1925.

Plate III

A

B